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To Basic Trends of Analytic Electrochemistry in Biology and Nanomedicine

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Introduction

In this mini-review (written under the Editor's request) the authors want to pay an attention of biologists and medical workers to the methods of the modern electrochemistry analysis (ECA) that now, occupy their important place in biology and medicine. As it is known a certain success in the ECA is related presumably with creation of new materials for different electrodes that give an expected response on an analyte (substrate, marker, biomarker etc.) Among the classes of materials suggested for these purposes the nanoparticles of different nature are proved to be the most effective (for example, for creation of sensors with different catalyst response and organic particles for creation of different biosensors). These problems are discussed in different conferences related to the ECA in the EC including Russia and the countries that formed the Union of Independent States. The usage of term "nano" in electroanalytical methods is appeared literally in the last decade. Nanoelectrochemistry, nanoelectroanalysis and nanomedicine imply one common feature, viz. and dimension of a particle that participates in the system detection/recognition on the presence of an analyte.

Now attention is paid to the recent trend in the development of electroanalysis in context of modern views on processes in the double electric layer, or interface, as a nanosize structure in an electrochemical nanoreactor, in which an analytical signal is generated. Therefore, the use of terms with the prefix "nano" in electroanalysis and some nanotechnologies is considered as one of basic trends, especially for voltammetry and amperometry. With the application of nanotechnologies, electroanalysis follows for the world trend in the choice of priority objects for investigations. Now the problem of the generic content becomes extremely actual and for its solution the colossal intellectual resources and financial funds are spent. We should mark two basic trends that are formed in the modern ECA [1-3].

The first trend is related to a wide application and detection of the (voltammograms) VAGs (in comparison with other methods) and selection of new research object as bio-analytical chemistry [1]. One can refer here the huge regions of research as pharmaceutical analysis and detection of different pathogenic agents. Here one can remind the detection of the different microelements and thiols [3].

The second trend is related to the modern revolution in construction of different microelectrode techniques and modification of their geometry. We remind here also the different electrode coating that increases essentially their stability, sensitivity and ability to new catalysts reactions. The last property opens"resonance" ability to the additive presenting in the solute and allows to detect its extremely low concentrations. In the process of its research and penetration of the methods inside of admissible scales new directions of the ECA appear. For example, the term "nanoelectroanalysis" stresses the scale 10-9m and this direction covers the nanoprocesses that take place near double electric layer. The nanoobjects that appear near electrode or closely related with it are classified in accordance with their dimension [1]:

A. **0D objects:** nanopoints (nanodiamonds, sulphides and tellurides of different metals, for example)

B. **1D objects:** nanowires and nanotubes presumably made from carbons with combination with different polymers.

C. **2D objects:** graphen, monolayers, "biological skin" layers.

D. **3D objects:** supramolecular layers, "fractal trees" aggregates and heterogeneous ensembles formed on electrodes.

For detection of different additives electrode design is important also. Combination of different strips, bands, combs help to increase their sensitivity and selectivity.

There are many examples of non-invasive amperometric sensors including carbon material and embedded into the textile material and located/imprinted on the skin (the so-called thinlayer variant of electrochemical cell or nanoreactor) [3]. This Figure 1 taken from [3] demonstrates the scheme of information extraction associated with redox properties of biological components. Other examples, that are given in the book [3] show that this nanotechnique helps in detection of some biomarkers for lung infections with the usage of electrochemical immunosensor in a microfluidic cell. The low detection limit is 0.003ng/ml. It turns to be effective also in analysis of the sweat extractions with the sensor that imprinted on the patient skin (detection of pH, glucose concentrations, urea traces) [3].

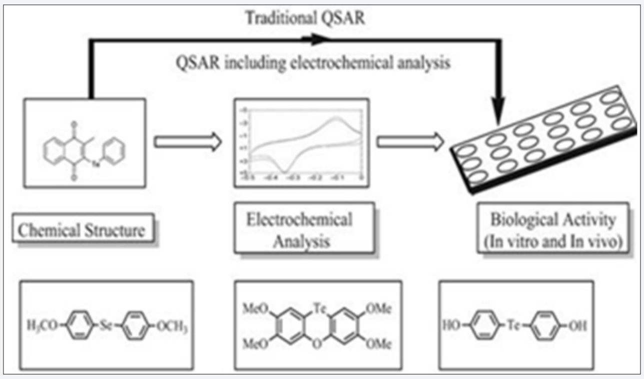

Figure 1: The scheme of information extraction associated with redox properties of biological components.

In the design of such sensors, the suggested nanotechnologies work just for their merits. To implement the concept of so-called electrochemical sensing, one should attain the required reproducibility of the surface of the modifying layer and of the robustness of the response. Conceptually, experts in biology and medicine are tightly close to electroanalysts in the goals and problems in this field of science. The response of a living cell in many respects has electric nature. Therefore, the experience of electroanalysts can be actively used in solving of problems of biomedicine, and not the specific analytical problems only, dealing with the determination of one or another analyte. The subject of inquiring in this case can be the process of gaining information about the functioning of living cells, individual receptors, or neurotransmission using nanotechnologies, eliminating the drawbacks of the approaches and associated with the capacitance and resistance of wires. However, this is the subject of bioelectronics rather than simple biosensoring. Here these two fields overlap. Note that the materials, i.e., nanoparticles used as components of living tissues for medical diagnosing (nanosilver, nanogold, iron nanooxides, etc.) have already attracted attention in nanoelectroanalysise as subjects of inquiry [4].

Electochemical detection of the unit neurons and large (organic) molecules implies elaboration of new nanodevices: nanoelectrodes, their ensembles as nanopores, nanochannels and etc. These new approaches are useful for neurochemistry (transmission of neurosignals). In this phenomenon (exocytosis) the different neurotransmitters participate. Electrochemical methods using the carbon fibers are extremely useful for detection of easy-oxidized molecular carriers (for example, dopamine, adrenaline, 5-hydrooxitryptamine and histamine) extracted by the unit neuron cell. In general, the control under cell secretions with the help of ECA and modern nanotechnologies is actual (The Reylie's premium 2013 awarded by Bo Zhang, Utah university, USA). These experiments contain valuable information as chemical identity, a quantity of the exertive material, frequency of these events etc. The pore materials (based on Si) allow creating analytical devices for detection of the unit molecules. These devices can be located inside the fabricated chip [5].

The trend mentioned above implies only the applications of new mathematical methods for extraction of useful information from the registered signals. Really, the analytical signal generated in electrochemical nanoreactor on presented marker or biological substrate has a complex nature. It means that the measured signal includes in itself the multi-stage response. Each stage has its own characteristics and their values are changed in certain limits (especially for non-equilibrium conditions of the electrolyze process). At low concentrations of analyte, the influence of uncontrollable factors/noise becomes essential. Therefore, the application of new mathematical methods for extraction of"purified" information from the surrounding electrochemical "noise" becomes important. These original methods have been found recently and proved their efficiency in solution of different problem associated with the ECA [6-8].

Concluding Remarks

Now one can say that including a period of few decades the ECA passed a long way starting from the registrations of the catalyst hydrogen waves on the hydrogen electrode up to disposable sensor-electrodes made with the usage of different nanotechnologies. The number of publications covering the different regions in biology and medicine grows in the geometrical progression and we do not see the opposite tendencies that could terminate their growth. One might expect new exceptional achievements of the ECA applications in biology and medicine.

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